

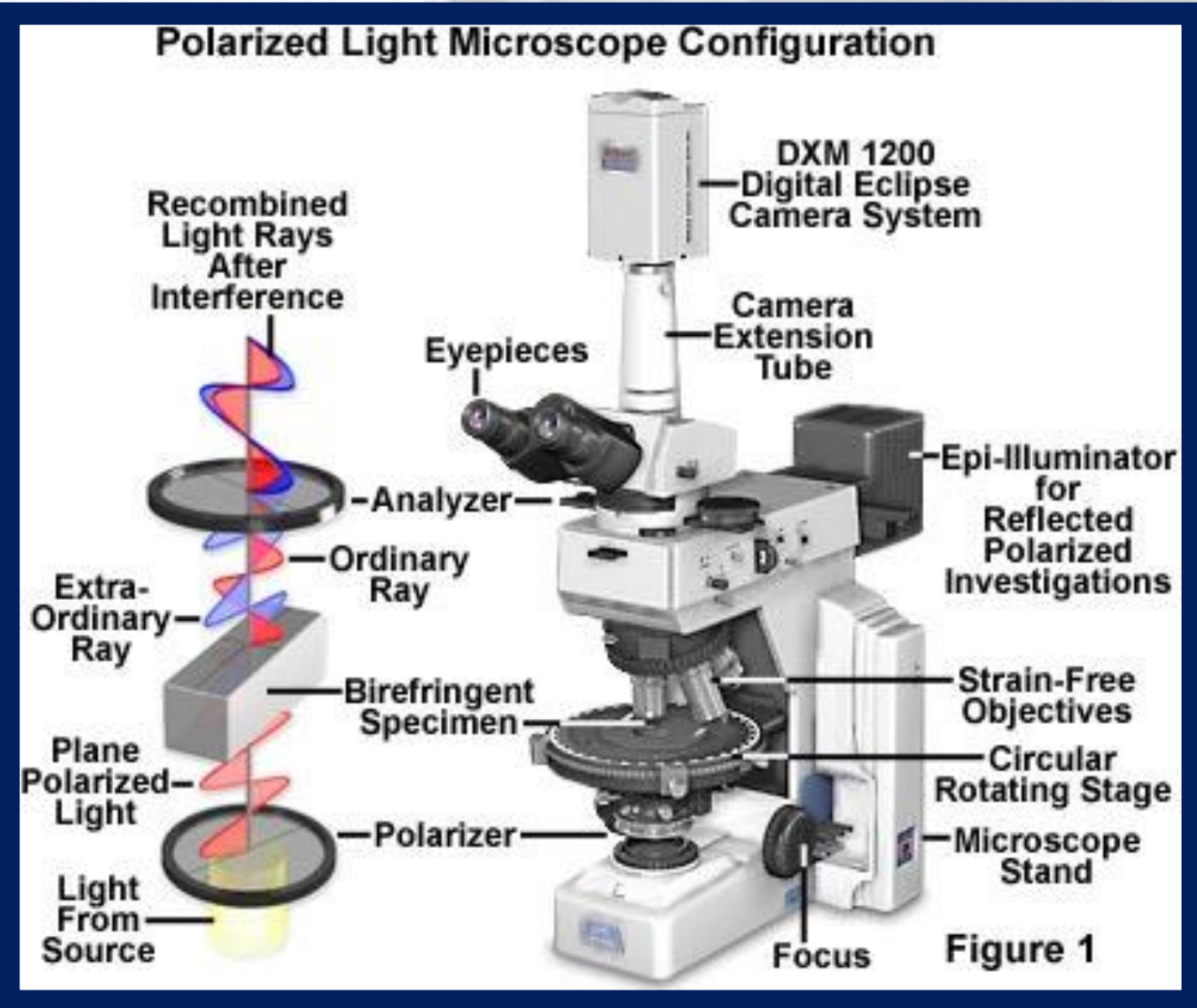
Introduction

Crawler Transporter (CT) #2 has been undergoing refurbishment to carry the Space Launch System (SLS). After returning to normal operation, multiple filters of the gear box lubrication system failed/clogged and went on bypass during a test run to the launch pad. Analysis of the filters was done in large part with polarized light microscopy (PLM) to identify the filter contaminates and the source of origin.



Polarized Light Microscopy (PLM)

PLM is a technique that uses polarized filters to filter light and examine unique optical properties of particles and fibers. The information gained yields clues to their identification and thus can be an extremely useful analytical technique for characterization of unknown materials.



No Polars

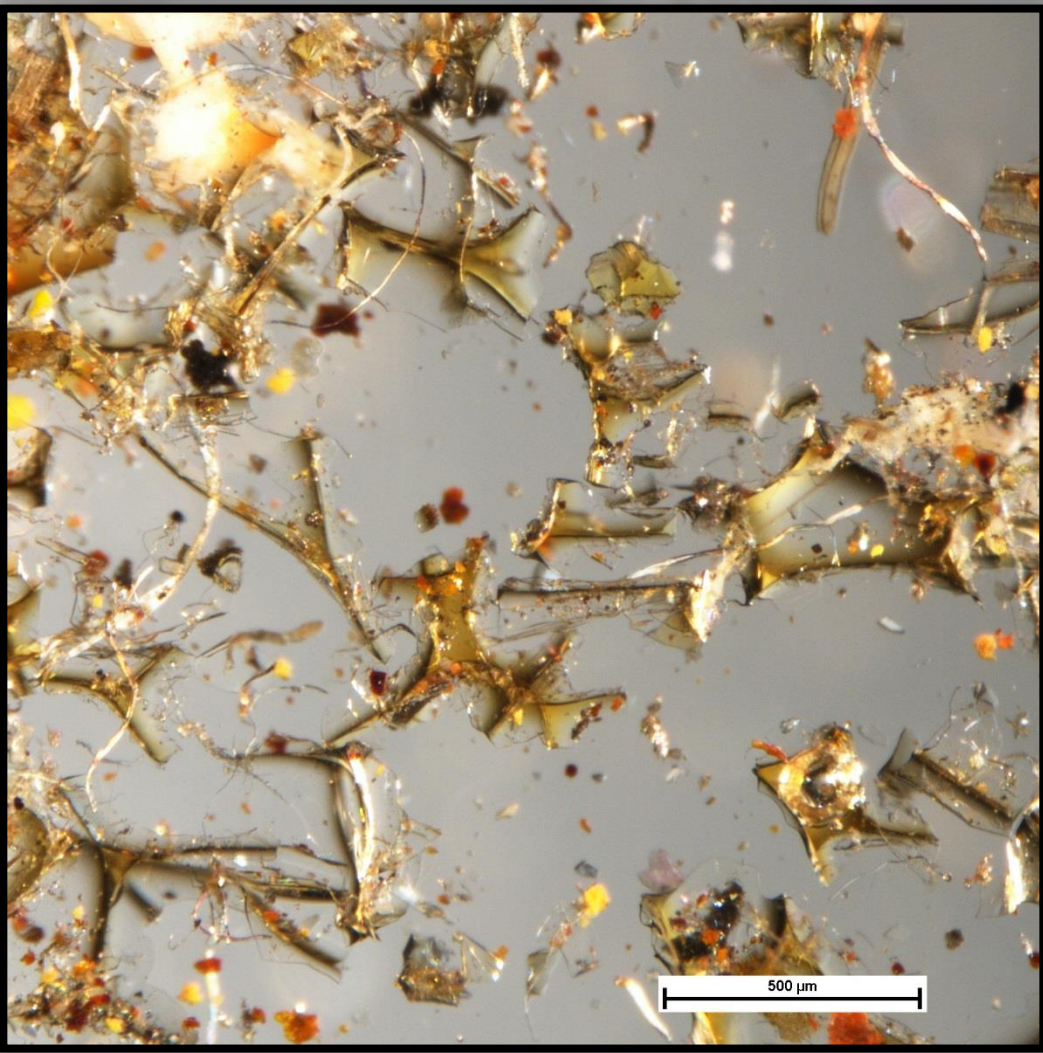
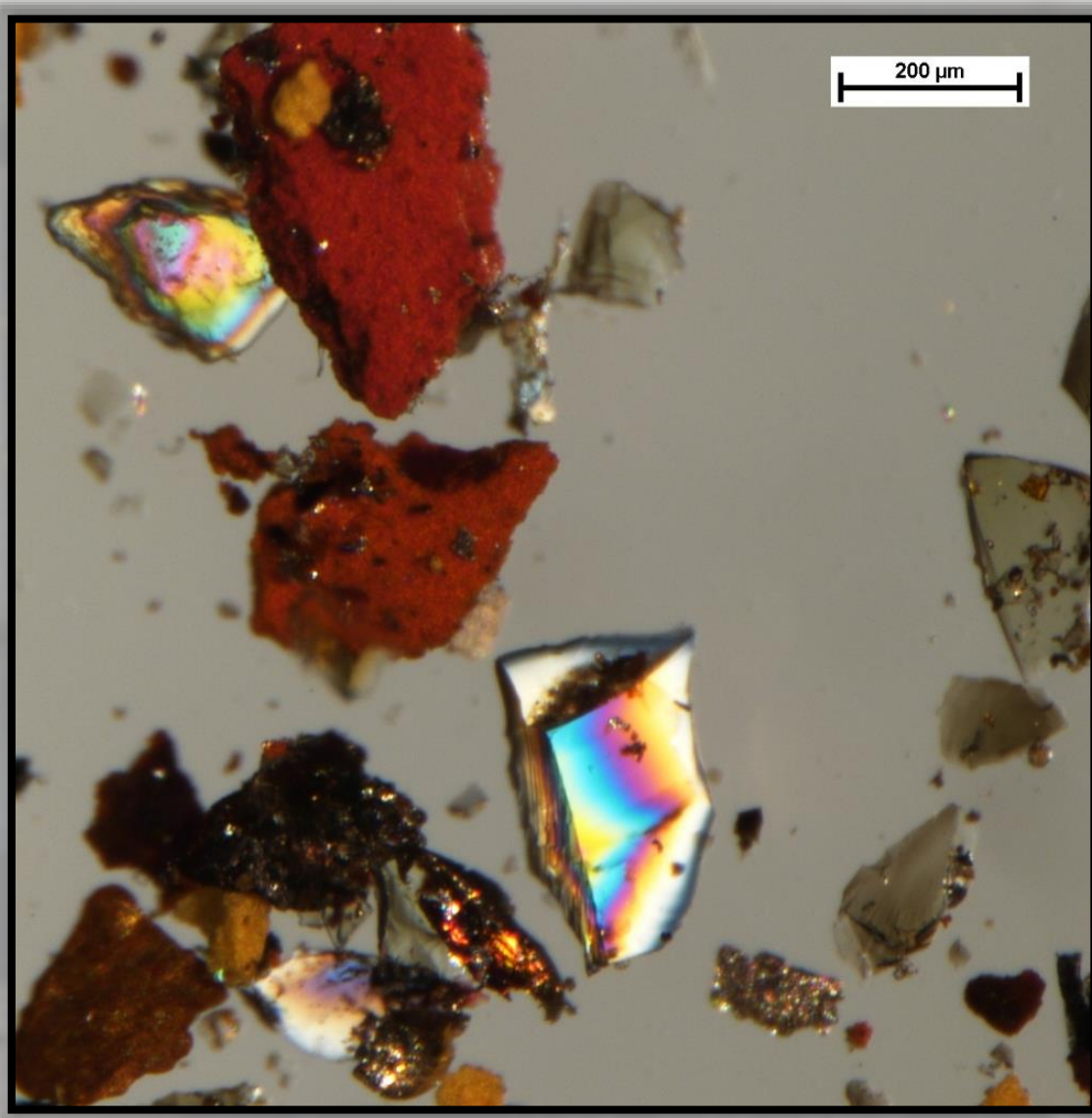
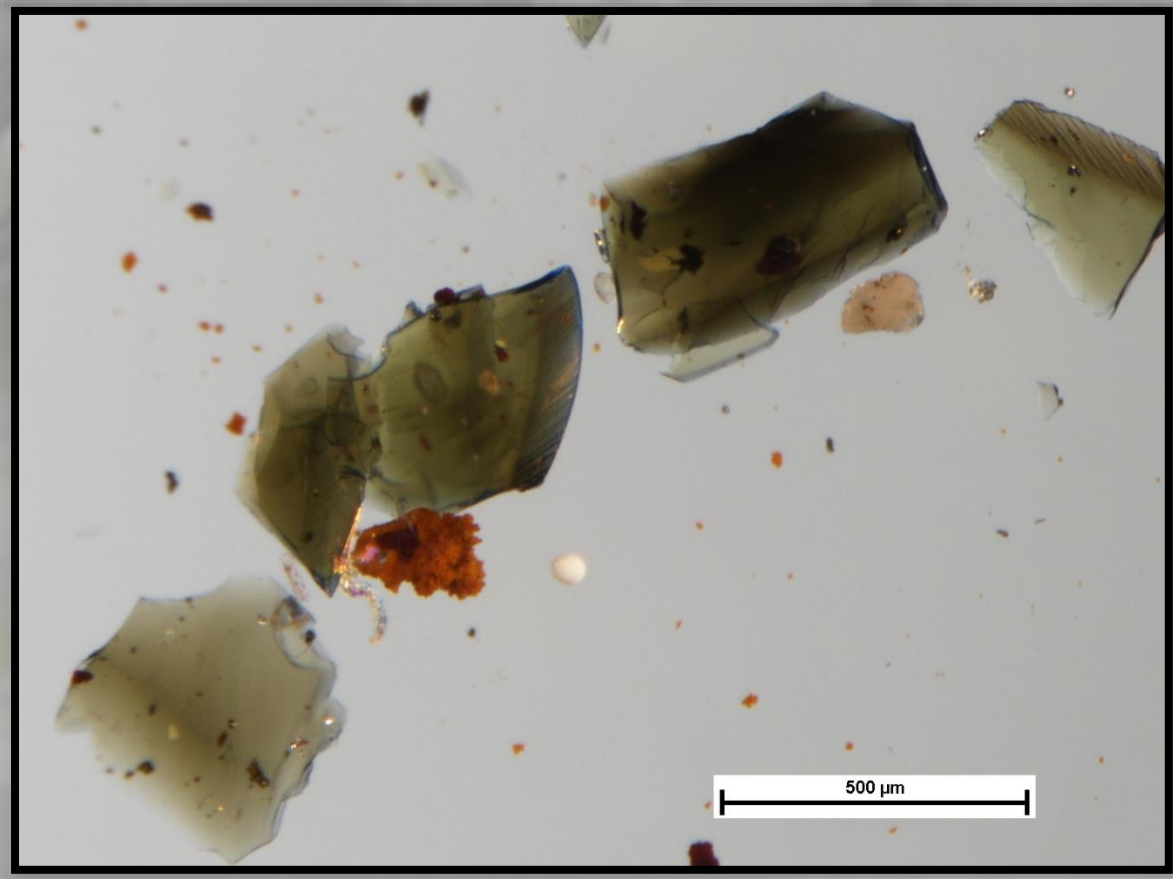
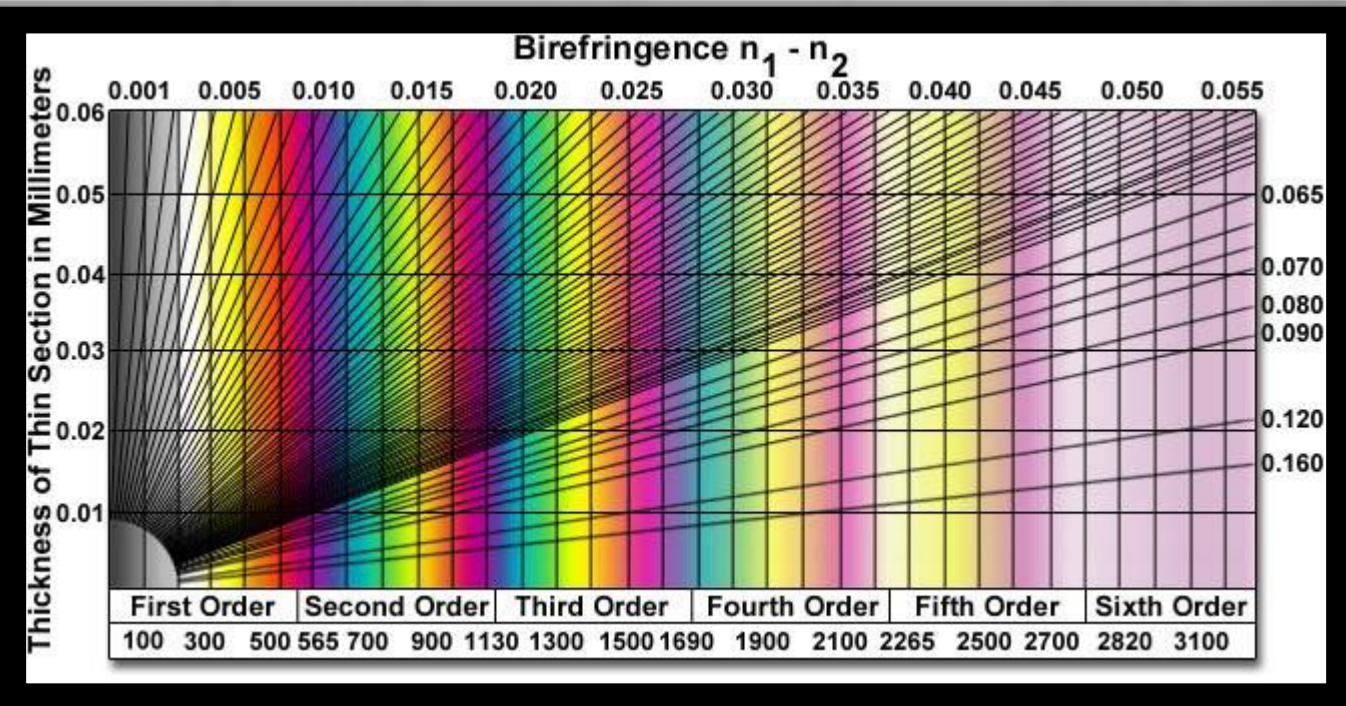
Without a polarizing filter, some basic characteristics can be observed, such as particle size, shape, surface features, color, transparency or opacity, crystallinity, number of phases, etc.



Single Polars

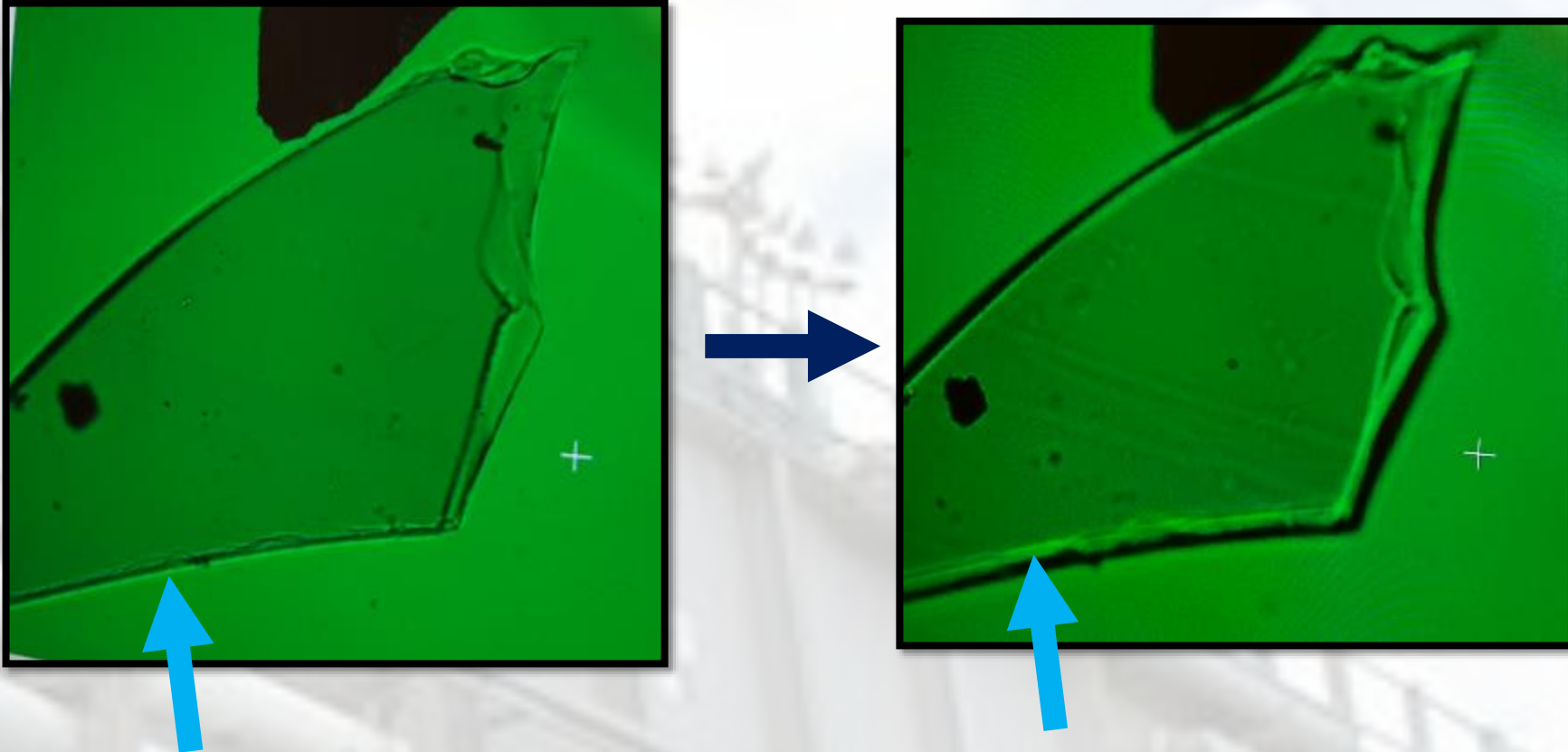
With a single polarizing filter, more advanced optical properties can be identified, such as:

- Isotropy vs. Anisotropy
- Pleochroism
- Birefringence
- Refractive Index



Becke Line

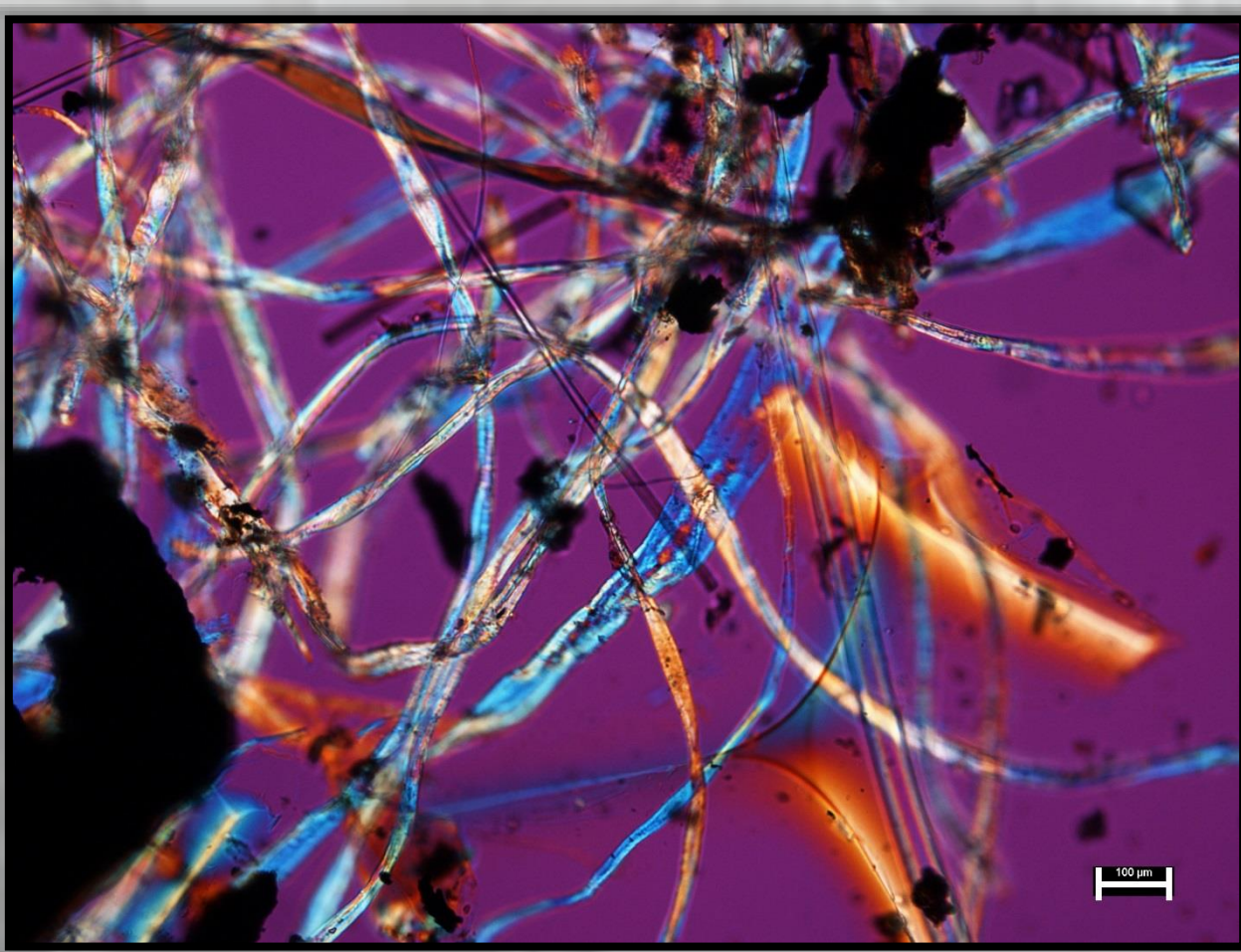
Immersion of the major mineral in an oil of known refractive index allowed for determination of the refractive index of the particles to be 1.660, and can be matched to a reference for ID.



Crossed Polars

Isotropy can be confirmed, and additional optical properties of birefringent materials can be examined, for example:

- Degree of birefringence
- Extinction angle
- Sign of elongation
- Interference figures
- Dispersion staining



Conclusions

The use of polarizing light microscopy was integral to the ID of the crawler solids. The solids were found to contain fibers (cotton, paper, fiberglass), and particles (green glass, quartz, urethane foam, steel corrosion byproducts, low alloy shavings, and a lithium soap based grease).

References: McCrone, Walter C. *Polarized Light Microscopy*. Chicago: McCrone Research Institute, 1993.
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Les Minéraux des Roches. A. Michel-Lévy and A. Lacroix. Librairie Polytechnique, Paris (1888).
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